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A Systematic Review of Delayed Umbilical Cord Clamping to Reduce Anemia among Newborn Infants

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ABSTRACT

Prolonged umbilical cord clamping during labour is one method to prevent anaemia in neonates; however, limited research on this treatment exists. This review aims to comprehensively assess the effects of delayed umbilical cord cutting and clamping on the anemia status of neonates. The review methodology employs a systematic review of the PubMed, CINAHL, and ScienceDirect databases. Keywords, inclusion and exclusion criteria are explicitly defined; the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is used to examine article selection, and critical assessment is conducted using JBI for randomised controlled trials (RCTs). A total of 11 papers from various countries were selected. The analytical results indicate that umbilical cord clamping and cutting enhance placental transfusion, augment iron reserves, diminish the risk of baby anaemia, increase red blood cell flow, and improve cardiopulmonary adaption. This measure diminishes and averts the occurrence of anemia in babies. Restricted implementation and evaluation of the efficacy of this measure in developing and multicultural nations, such as Indonesia. The socialisation and integration of this action within health services enhances the health of newborns.

Keyword: Anemia, Delayed cord clamping, Newborn

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1. Introduction

The prevalence of iron deficiency anemia in full-term newborns between the ages of 0 and 6 months remains high at around 40.8% (Ahmaniyah et al., 2018). Iron deficiency anemia in newborns occurs due to heart and lungs changes of oxygenation during the transition from fetal to newborn period, from approximately 8-10% to 50% (Ahmaniyah et al., 2018). One effort to prevent anemia in infants is to ensure that the placenta provides blood for them through the umbilical cord. The practice of not clamping the umbilical cord immediately after birth, and instead wait a defined period to allow placental blood to flow to the newborn is known as delayed cord clamping (DCC) (Chaudhary et al., 2023). The exact time varies between studies, but current World Health Organization (WHO) and American College of Obstetricians and Gynecologists (ACOG) standards are broadly aligned for a minimum of 30-60 seconds post birth (American College of Obstetricians and Gynecologists, 2020; WHO, 2014). Growth abnormalities are among the long-term issues

that could arise in infants with anemia. Additionally, infants who have previously experienced anemia are more vulnerable to infection (Asfarina et al., 2020). Previous studies have analyzed the indications, advantages, and benefits of childbirth care, including DCC, but there is limited information that systematically explores the effects of such care on newborns.

As science advances, childbirth care has also evolved, including DCC. As the WHO recommends to wait for 30-60 seconds after birth, there is still much debate regarding the exact time for optimal umbilical cord clamping (Mordi et al., 2017). Particularly in Indonesia, the formal recommendation is at about two minutes after birth (Marlina et al., 2023). However, the actual practice is mixed; an implementation of DCC delivery with clamping period after 24 hours has been carried out at a clinic in East Jakarta, and 1,631 babies have undergone this method (Carolin et al., 2020). Therefore, duration of DCC can be applied according to different recommendations, and because the areas implementing DCC are still limited, the most effective time to result in the best effects of DCC are still debated.

DCC allows the placenta to transfer blood to the baby at a greater scale, which oftentimes result in an increase of blood volume to a third of the baby's weight (Andersson & Mercer, 2021). Iron in the blood helps babies store more iron, which is crucial for their brain development (Joo et al., 2016). The debate over DCC arises in cases of fetal distress and/or neonatal asphyxia requiring immediate resuscitation of the newborn, in which it is considered to postpone the baby's rescue (Qian et al., 2019). However, it is precisely in these situations that DCC provides the most significant benefits. Fetal distress due to intrauterine umbilical cord compression is caused by oxygen-rich blood being unable to enter the fetus from the placenta, resulting in a decrease in the volume of oxygen-rich blood in the fetal circulation (Ott et al., 2022). Increasing oxygenated blood circulation through placental transfusion with DCC has a very positive effect on fetal distress and should be considered the first step in newborn resuscitation (Kc et al., 2019). According to the Basic Newborn Resuscitation Guidelines by WHO, if the skills and equipment are available, positive pressure ventilation (PPV) resuscitation can be performed without first cutting the umbilical cord (Ott et al., 2022; World Health Organization, 2012). However, if there is no prior experience, newborns requiring PVR should have their umbilical cord clamped immediately so that ventilation resuscitation can be performed as soon as possible (Ott et al., 2022). The efforts made should, of course, take into account the newborn's condition.

As a physiological way of umbilical cord care, WHO highlights the significance of combining approaches to mother and newborn care, one of which is delaying or not clamping/cutting at all. Normal delivery care, which is the standard of delivery assistance in Indonesia by health workers, does not clearly specify the optimal duration for cutting the umbilical cord for babies (Agustini & Roeslani, 2016). This intervention still requires further evidence. Additionally, according to WHO, DCC can boost iron levels, which can lower infant anemia by 60%, intraventricular hemorrhage by 59%, necrotizing enterocolitis by 62%, sepsis, and the requirement for blood transfusions in preterm infants (WHO, 2014). With more supply of iron, it is hoped that the blood needs of premature infants can be met. DCC is one strategy to prevent fetal distress and increase iron supply in newborns, which impacts the reduction of anemia incidence in infants. Previous studies have analyzed the indications, advantages, and benefits of childbirth care, including DCC, but there is limited information that systematically explores the effects of such care on newborns. This review aims to systematically assess the effectiveness of childbirth care with DCC on the anemia status of infants globally as measured by hemoglobin and iron levels.

2. Methods

This review uses a systematic literature review approach. Articles discussing the effectiveness of applying the DCC method to newborns were searched by authors using international databases, namely PubMed, CINAHL plus, and ScienceDirect. These databases were chosen for their ease of access to full-text articles, allowing for in-depth and detailed analysis. To search for relevant articles, the keywords applied by the authors include ("delayed cord clamping" OR "delayed umbilical cord clamping") AND (delivery OR birth OR labor OR childbirth) AND (anemia OR ferritin OR hemoglobin). Based on the predefined keywords, we will evaluate the effectivity of DCC based on its effects in levels of anemia, ferritin, and hemoglobin. Inclusion criteria: Full text, academic journal, published 2014-2025, use English as the publication language, and applies the randomized control trial (RCT) study design. Exclusions: Non-human samples. Due to limited studies published, subgroup analysis for term-preterm, cesarean-vaginal, and special populations were not considered for subgroup outcome analysis. Studies with RCT designs were selected in this systematic review because their design minimizes bias and confounding, providing the most reliable evidence for causal relationships and high internal validity. Articles with a RCT approach are the most reliable for evaluating the interventions used,

thus demonstrating that the interventions carried out were truly feasible to find the most effective impact of DCC on anemic infants. The time frame of articles published between 2014 and 2025 was determined so that the content of the articles would still be relevant. Around 2014, major international guidelines began to more consistently recommend and define DCC, leading to greater uniformity in intervention protocols, timing thresholds, and neonatal care practices. As an example, the World Health Organization updated its recommendations on umbilical cord clamping in 2014, and subsequent guidance from professional bodies such as the ACOG further reinforced standardized definitions and implementation (American College of Obstetricians and Gynecologists, 2017; WHO, 2014). Studies published prior to this period may vary in their definitions of DCC and were conducted under differing clinical standards, which could introduce heterogeneity with current practice.

To guarantee the review process's validity and reliability, standardized and transparent procedures were applied during screening, study selection, and data extraction. Prior to starting the article selection process, all authors clearly defined their roles to maintain methodological rigor. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, which include (1) defining the topic and criteria, (2) identifying the sources of information, (3) choosing pertinent literature, (4) gathering articles, and (5) analyzing articles, were used in the selection of articles for review (Page et al., 2021). The article selection process followed the PRISMA steps described in Figure I. Two authors (DA and YS) conducted the article search using the same keywords in different databases (one author searched in PubMed and ScienceDirect; the other searched in CINAHL). The same two writers separately assessed the articles based on the abstract and title after the article search, and then they evaluated the full text using predetermined inclusion and exclusion criteria. Based on the search results from the three databases, 2,946 articles were found. Articles were obtained from the PubMed database (311 articles), ScienceDirect (7 articles), and CINAHL (2,628 articles). These articles were then stored in the Mendeley reference management program to check for duplication, leaving 520 articles. The researchers read the titles and abstracts to eliminate articles based on their suitability for the research objectives. There were 392 articles with titles that did not match the literature review and 117 articles with abstracts that did not match, resulting in 11 articles for analysis. Critical appraisal was conducted using JBI for RCTs. Discrepancies were discussed and solved, and when necessary, a third author (EE) was consulted to reach consensus. A standardized form to extract data from articles was developed and tested collaboratively by three authors (RW, YK, EE) to ensure consistency and completeness. Data extraction was then independently done by two authors (RW and YK), with cross-checking by an additional team member (AS) to minimize errors and reduce bias. All co-authors contributed to the protocol for review, supervision of the review process and verification of extracted data and synthesized findings. All agreements related to the review process were monitored throughout, and adherence to the PRISMA guideline was maintained to enhance transparency and consistency.

The literature search for this review was limited to electronic databases, and no additional search strategies such as manual reference screening, citation tracking, or grey literature searches were conducted. This approach was adopted to maintain a focused search strategy based on predefined databases and search terms. The selected databases were considered comprehensive, appropriate, and trustworthy, as they contain reputable published articles that have gone through a rigorous review process. The databases were considered the suitable sources for relevant studies on delayed cord clamping. Article analysis was done in three stages involving three authors. The first stage involved fully reading the articles and understanding their content (RW, YK, EE, TP). The second stage involved extracting the findings and summarizing them in tabular form (RW and YK). The writers examined the content of each article for similarities and differences in the third step, summarizing the results in categories (RW, YK, TP).

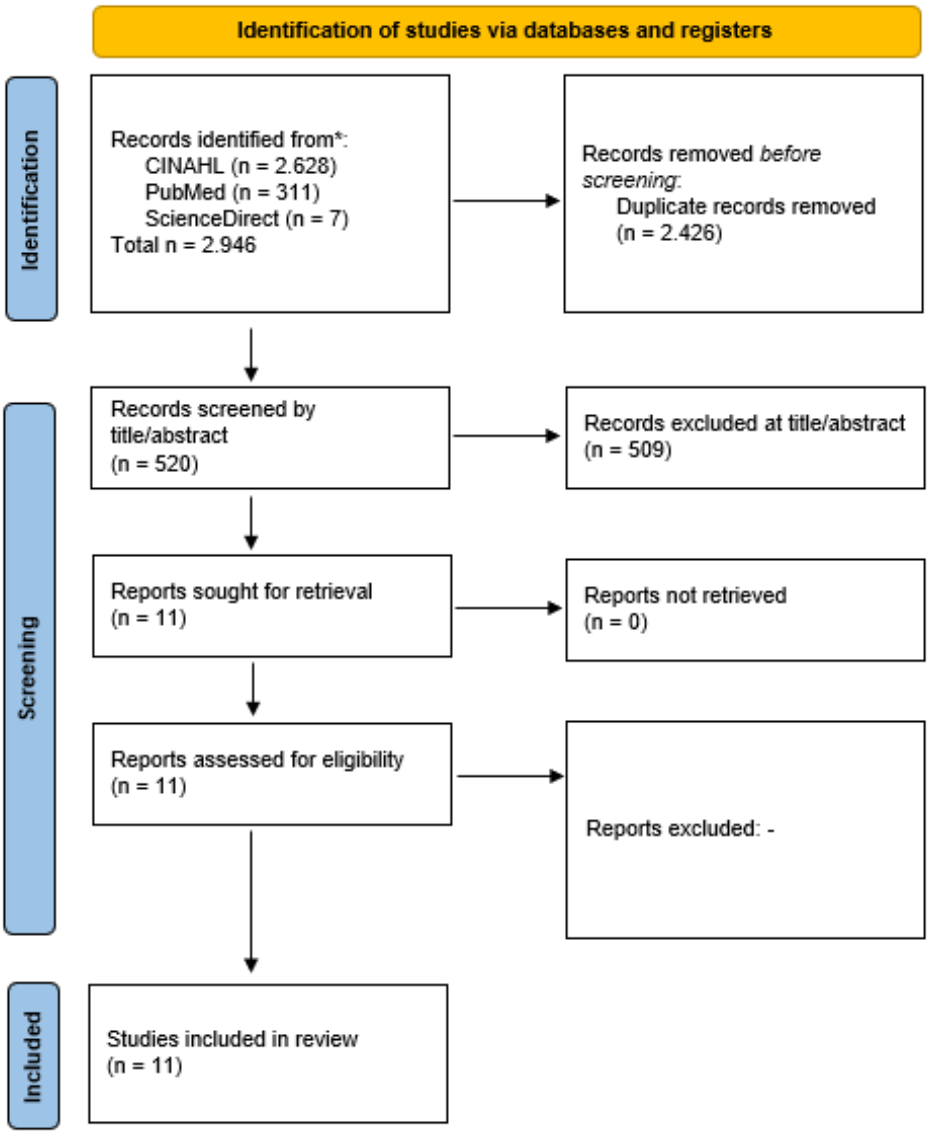

Figure 1 PRISMA Selection Diagram

This review uses The Joanna Briggs Institute (JBI) Critical Appraisal for assessing the selected journals' feasibility. The 13 items for Randomized Controlled Trials (RCTs) were used to assess all of the journal articles obtained from the literature search. The synthesis of the data outcome shows that all articles selected by the PRISMA guidelines are feasible (>70%) to be included in the review (Table 1).

Table 1 Characteristics of Study Participants

Author, Year	JBI Checklist (%)	Literature Quality Assessment
(Mercer et al., 2016)	85% (11/13)	Feasible
(Alzaree et al., 2018)	77% (10/13)	Feasible
(KC et al., 2016)	77% (10/13)	Feasible
(Dipak et al., 2017)	85% (11/13)	Feasible
(Mangla et al., 2020)	77% (10/13)	Feasible
(Mercer et al., 2018)	85% (11/13)	Feasible
(De Bernardo et al., 2020)	77% (10/13)	Feasible
(Yunis et al., 2021)	85% (11/13)	Feasible
(Sahoo et al., 2020)	85% (11/13)	Feasible
(Shinohara et al., 2021)	77% (10/13)	Feasible
(Güner & Saydam, 2021)	85% (11/13)	Feasible

3. Results

Based on the data extracted, the articles provided evidence of DCC benefits in newborns, including higher hemoglobin concentrations due to increased placental transfusion, additional iron supply, an increase of red blood cell flow to vital organs, better cardiopulmonary adaptations, and lower chance of anemia as a baby (KC et al., 2016). The articles showed that infants who received the DCC treatment showed no symptoms of hyperbilirubinemia or symptomatic polycythemia, especially in full-term newborns (Mangla et al., 2020). Other studies also discussed the benefits of DCC in infants at 4 months of age, in which they showed an average ferritin concentration 45% higher and a lower prevalence of iron deficiency (Mercer et al., 2018). This is advantageous for the infants' growth, as a higher ferritin concentration can promote greater myelin content in the brain, affecting earlier maturation of growth in relation to motor, visual, and sensory processing (Mercer et al., 2018). In relation to supporting the health of red blood cells in infants, DCC also increases the hematocrit without causing additional side effects such as double volume exchange transfusion (De Bernardo et al., 2020). Although beneficial for overall hemoglobin and iron levels in infants, DCC has no effect on the infants' heart rate, oxygen saturation, temperature, and glycemia (Dipak et al., 2017).

Study characteristics, such as distribution of countries (Figure 2) and year of studies (Figure 3) are presented to provide context for the evidence discussed in this review. Based on the 11 articles analyzed, nothing has been done in Southeast Asia, including Indonesia. The studies were conducted across a diverse range of countries, with the highest number originating from India. Other Asian countries, including Turkey, Japan, and Nepal were represented by one study each, as well as Italy. Egypt and USA however, contributed two studies, indicating moderate representation of DCC evaluation from these settings. This distribution suggests that the evidence provided is geographically varied.

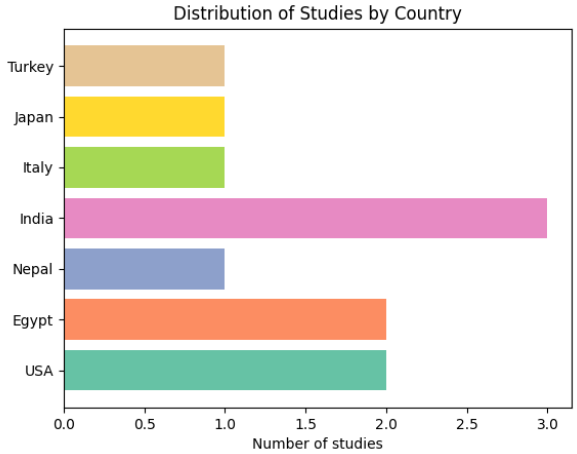

Figure 2 Distribution of Countries

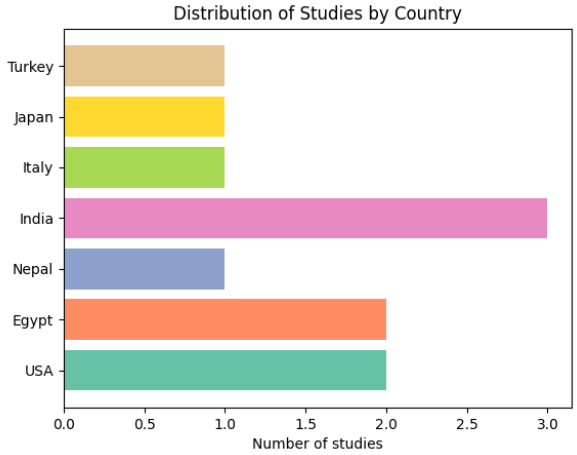

Figure 3 Year of Studies

The latest research was conducted in 2021, five years ago, and updated research is needed to identify aspects that have not been analyzed previously. This distribution shows the gradual increase over time, since

the first time WHO and ACOG created the guidelines in 2014. This pattern suggests growing research interest in DCC in recent years. Various theories were used as the basis for the research, with the following overview:

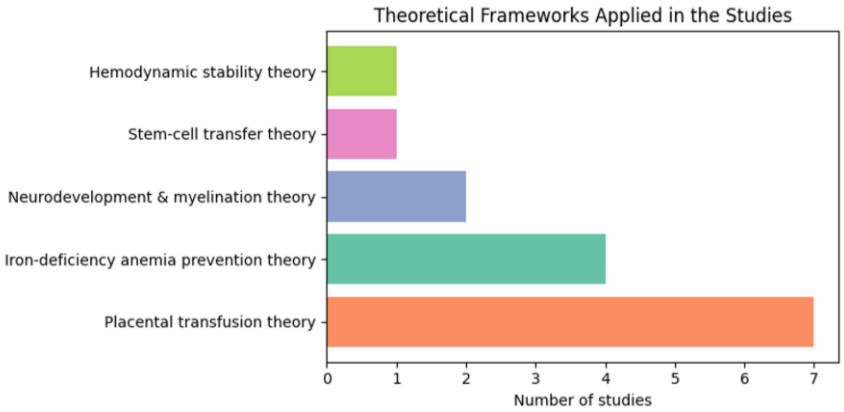

Figure 4 Theoretical Frameworks

From a physiological perspective, blood transfusion in the placenta will support a smoother cardiovascular transition from fetal life in the womb to life outside the womb by increasing blood preload, stabilizing blood pressure, and increasing oxygen to the tissues. The delay time for cutting the placenta varies, from less than 1 minute to 5 minutes.

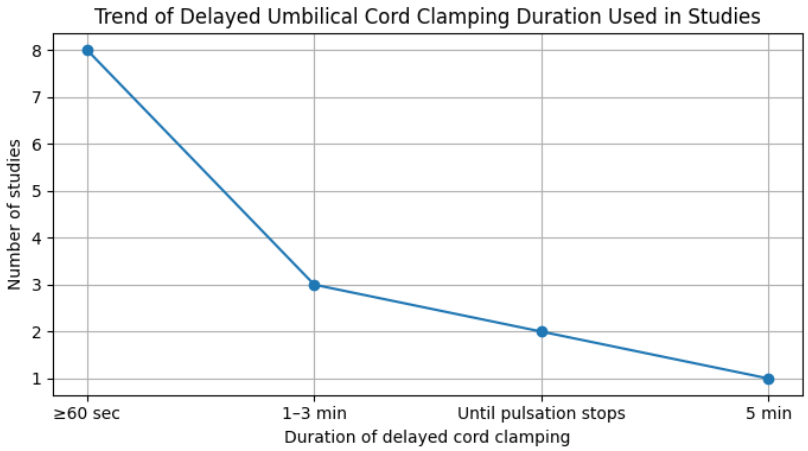

Figure 5 Delay Time

4. Discussion

Based on the literature reviewed, three of the eleven articles analyzed found that DCC had a positive effect on conditions that increased hemoglobin and prevented anemia in newborns (Mercer et al., 2016; Shinohara et al., 2021; Yunis et al., 2021). DCC increases endogenous hematopoietic stem cell transfusion in newborns, improves brain oxygenation in premature infants, reduces the chance of iron deficiency anemia in full-term infants (Yunis et al., 2021), increase blood flow between placenta and infant (30.8 ml kg-1, $P < 0.001$) (Mercer et al., 2016), and higher hematocrit levels at days 3-5 ($P < 0.01$) (Shinohara et al., 2021). Early hematological advantages of DCC are shown in term newborns without symptomatic polycythemia or elevated hyperbilirubinemia (Mangla et al., 2020). The results of two other articles discussing the effect of DCC on infant iron levels indicate that at 4 months of age, infants using the DCC method had an average ferritin concentration 45% higher and a lower prevalence of iron deficiency (Andersson et al., 2011; Mercer et al., 2018).

4.1. Delayed Cord Clamping and Increased Hemoglobin

Red blood cells include a protein called hemoglobin, which transports oxygen from the lungs to all of the body's tissues and transports carbon dioxide from those tissues back to the lungs for release into the atmosphere (Farid et al., 2023). Red blood cells cannot carry oxygen and carbon dioxide effectively if the quantity or form of hemoglobin is incorrect, and anemia is one of the health issues that this may cause (Davis, C.P, 2019).

According to WHO, anemia is a condition when the body does not have enough red blood cells to meet its physiological needs (WHO, 2025). According to the National Heart, Lung, and Blood Institute, anemia can occur in children and infants (Gallagher, 2022). Newborns can experience anemia for several reasons, including the body not producing enough red blood cells, commonly known as physiological anemia (Gallagher, 2022). This type of anemia occurs because the infant's body is growing rapidly and needs time to produce red blood cells. Anemia can cause serious consequences if left untreated for a long time (Tabrizi & Barjasteh, 2015). Problems to vital organs such as the heart may appear, such as irregular and fast heartbeat, which may develop into cardiomegaly or heart failure (Jimenez et al., 2015). In the long-term, anemia in infants may cause complications such as growth disorders and higher susceptibility to infection (Asfarina et al., 2020). If anemia is brought on by the quick breakdown of red blood cells, bilirubin production will rise, resulting in jaundice, a yellowing of the skin and whites of the eyes (Yunis et al., 2021). Anemia can also cause problems with infant growth and development (Yunis et al., 2021).

DCC in newborns has been proven to be beneficial for newborns. Improved placental transfusion, which raises hemoglobin concentrations, more iron storage and reduces anemia later in infancy, improved cardiac adaption, and greater red blood cell flow to essential organs are some of these advantages (KC et al., 2016). DCC is advantageous for full-term infants, while iron deficiency anemia in infants is linked to developmental difficulties (KC et al., 2016). Infants' ferritin and hematocrit levels also vary significantly. Most infants who received DCC intervention showed better hemoglobin and iron levels (Andersson et al., 2011).

4.2. Delayed Cord Clamping and Increased Hematocrit

Four of the 11 articles analyzed stated that DCC can increase hematocrit and ferritin levels in newborns (De Bernardo et al., 2020; Dipak et al., 2017; Sahoo et al., 2020; Yunis et al., 2021). Hematocrit, or the number of red blood cells in the blood that deliver oxygen to every cell in the body so that it can function effectively, can be raised by DCC (Sahoo et al., 2020). If a person's hematocrit is low, it will cause various health problems due to oxygen deficiency (Yunis et al., 2021). DCC increases venous hematocrit in moderate to severe immune hemolytic anemia without increasing side effects such as double volume exchange transfusion and hyperbilirubinemia, with infants who received DCC had a higher packed cell volume at hour 2 of birth (P 0.03) (Sahoo et al., 2020). DCC is commonly performed on premature infants, those with intrauterine growth restriction (IUGR), and those with placental insufficiency (De Bernardo et al., 2020). In this instance, there is no increased risk of polycythemia or substantial hyperbilirubinemia, but there is a significant stem cell transfusion and much greater hemoglobin and hematocrit percentages at delivery due to DCC (Yunis et al., 2021). During the perinatal transition, DCC significantly improves the hematocrit (P<0.001), temperature (P=0.004, P=0.008), blood pressure (P<0.001), and urine output (P<0.001) of premature newborns (Dipak et al., 2017).

4.3. Delayed Cord Clamping and Increased Ferritin

When full-term infants who received DCC intervention reach the age of four months, they reported higher ferritin levels (96.4 vs 65.3 ng/dL, P = 0.3) and higher brain myelination in areas critical for early functional development (Mercer et al., 2018). The timely distribution of vital lipids and micronutrients, such as iron, is necessary for process-driven activities, myelin sheath development, and maintenance; significantly developing localized areas around the brain, including the brainstem, cerebellum, parietal and occipital white matter, and the inner capsule. According to research, receiving a placental transfusion at birth can help with the myelination process during the first few months of life and enhance iron stores, which are represented by ferritin (Mercer et al., 2018). This is crucial, as rapid and efficient brain communication and signaling is supported by myelinated axons (Mercer et al., 2018). Given the various benefits of DCC, it can be implemented in Indonesia, especially since most births still involve normal delivery with immediate cord clamping.

4.4 Limitations

It is important to take into account the limits of this review. The search approach was restricted to specific electronic databases; and no supplementary search methods such as citation tracking, manual reference screening, or grey literature searches, were carried out. As a result, relevant studies, particularly those not indexed in the chosen databases or published in grey literature sources, may have been omitted. This potentially limit the comprehensiveness of the evidence base. Therefore, while the review provides a structured synthesis of available studies, the findings should be interpreted with consideration of this limitation.

5. Conclusion

Based on the analysis conducted, we concluded that DCC can have an impact on oxygen supply in the body, hematocrit status, hemoglobin, and iron levels, which increase significantly without causing hyperbilirubinemia. Increased placental transfusion, which results in higher hemoglobin concentrations, more iron storage, reduced anemia later in infancy, increased red blood cell flow to essential organs, and improved cardiopulmonary adaption are among the advantages of the DCC approach. Additionally, DCC is one way to reduce or prevent iron deficiency anemia in infants. Even in the absence of anemia, iron deficiency in infants has been linked to developmental problems. Even in regions where iron deficiency anemia is not as common, DCC seems to be advantageous for full-term newborns. In regions crucial for early functional development, DCC exhibits enhanced brain myelination and elevated ferritin levels. Increased iron stores, symbolized by ferritin, may arise from placental transfusion at birth and aid in myelination during the first several months of life. This is crucial because myelinated axons enable quick and effective brain messaging and communication.

The author acknowledges that this review process still has its limitation; however, it is hoped that this article will provide valuable insights, particularly for healthcare workers who are directly involved in maternal and neonatal care, as well as families and the broader community. This review is hoped to increase knowledge of DCC's advantages and encourage its appropriate implementation to support infant health. Despite limitations in available knowledge and literature sources, this review may serve as a foundation for future research and for the wider development and implementation of the DCC method in Indonesia. several contextual factors should be considered to support the implementation of a standardized DCC in Indonesia. potential barriers include limited awareness and training among healthcare providers, variations in delivery room protocols, concerns regarding neonatal resuscitation during delayed clamping, and limited availability of supporting equipment in some healthcare facilities. Facilitators for implementation include international guideline recommendations and the feasibility of integrating DCC into routine delivery care with the appropriate health worker training. Further local research and policy support to create a culturally-aligned and standardized protocol is needed to strengthen evidence-based implementation of DCC in diverse maternal and neonatal care settings in Indonesia.

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APPENDIX

Appendix 1. Search Strategy and Process

PICO

PICO			Keywords
Population (P)	:	Newborns, infants undergoing childbirth	Delivery, birth, labor, childbirth
Intervention (I)	:	Delayed cord clamping (DCC), delayed umbilical cord clamping	"Delayed cord clamping", "delayed umbilical cord clamping
Comparison (C)	:	-	-
Outcome (O)	:	Infant anemia status and iron-related parameters	Anemia, ferritin, hemoglobin

Database 1. PubMed (311 articles)

Filters applied	Search terms	Records identified
• Publication years: 2014-2025 • English language • Full text	("delayed cord clamping" OR "delayed umbilical cord clamping") AND (delivery OR birth OR labor OR childbirth) AND (anemia OR ferritin OR hemoglobin)	152

Database 2. ScienceDirect (7 articles)

Filters applied	Search terms	Records identified
• Publication years: 2014-2025 • English language • Full text	("delayed cord clamping" OR "delayed umbilical cord clamping") AND (delivery OR birth OR labor OR childbirth) AND (anemia OR ferritin OR hemoglobin)	7

Database 3. CINAHL (2,628 articles)

Filters applied	Search terms	Records identified
• Publication years: 2014-2025 • English language • Full text	("delayed cord clamping" OR "delayed umbilical cord clamping") AND (delivery OR birth OR labor OR childbirth) AND (anemia OR ferritin OR hemoglobin) NOT ("standard cord clamping" OR "standard childbirth care")	2,628

All records retrieved from the databases were exported into reference manager Mendeley for organization and duplication removal. Following duplicate removal, titles and abstracts were independently screened by two authors according to predefined inclusion and exclusion criteria. Eligible studies then underwent full-text assessment to determine final inclusion in the review as demonstrated in the PRISMA flowchart. Disagreements during the screening and selection process were resolved through discussion and consensus among the authors.

Appendix 2. Data Extraction Table

Table 2. Extraction of Articles

No	Author	Context	Country	Research Methods	Analysis	Result
1	(Mercer et al., 2016)	Routine immediate cord clamping is widely practiced despite limited evidence; concerns exist about hyperbilirubinemia and polycythemia	USA	Quantitative; Prospective Randomized Controlled Trial (RCT)	Statistical analysis (t-test, χ^2, Wilcoxon rank-sum; ITT & per-protocol)	DCC resulted in higher hemoglobin and lower residual placental blood volume without increased hyperbilirubinemia
2	(Alzaree et al., 2018)	High prevalence of physiological anemia in term infants in low-resource settings	Egypt (Cairo)	Quantitative; Randomized Controlled Trial	Inferential statistics (t-test, χ^2, correlation)	Both methods improved hemoglobin; cord milking slightly superior, but not clinically significant
3	(KC et al., 2016)	Very high infant anemia prevalence (72–78%); lack of RCTs beyond neonatal period in LMICs	Nepal	Quantitative; Facility-based RCT (protocol)	Planned statistical comparison of outcomes	Expected reduction in anemia and improved iron stores with DCC
4	(Dipak et al., 2017)	Premature infants are vulnerable to anemia, hypothermia, and hemodynamic instability	India	Quantitative; Randomized Controlled Trial	Statistical analysis (ANOVA, post-hoc comparison; ITT)	DCC significantly improved hematocrit, temperature, blood pressure, and urine output
5	(Mangla et al., 2020)	Uncertainty remains whether intact umbilical cord milking (MUC) provides superior hematologic benefits compared with delayed cord clamping (DCC) in late preterm and term neonates	India	Quantitative; Open-label Randomized Controlled Trial	Statistical analysis (t-test, Chi-square; intention-to-treat)	MUC resulted in higher venous hematocrit at 48 h and 6 weeks; ferritin levels were similar; no increase in adverse outcomes

6	(Mercer et al., 2018)	Early iron deficiency may impair brain myelination; limited human evidence linking placental transfusion to brain development	USA	Quantitative; Partially blinded Randomized Controlled Trial	Statistical analysis (GLM, voxel-wise MRI analysis, correlation analysis)	DCC increased ferritin levels and brain myelin content at 4 months; no early neurodevelopmental score differences
7	(De Bernardo et al., 2020)	Benefits of DCC are established after vaginal birth, but evidence is limited for elective caesarean section deliveries	Italy	Quantitative; Open-label Randomized Controlled Trial	Statistical analysis (ANOVA, Chi-square)	DCC increased hematocrit and bilirubin at 72 h without affecting SpO_2, HR, temperature, or need for phototherapy
8	(Yunis et al., 2021)	Feasibility and benefits of delayed cord clamping (DCC) are uncertain in preterm infants with placental insufficiency, who are often excluded from DCC studies due to concern about limited placental blood reserve	Egypt	Quantitative; Prospective pilot Randomized Controlled Trial	Statistical analysis (t-test, Mann–Whitney U, Chi-square, regression, correlation analysis)	DCC significantly increased $CD34^+$ stem cell percentage, higher hemoglobin at birth and at 2 months, fewer anemia episodes, and shorter oxygen therapy duration
9	(Sahoo et al., 2020)	DCC is avoided in Rh-alloimmunised infants due to fear of hyperbilirubinemia and anemia; evidence is scarce	India	Quantitative; Open-label Randomized Controlled Trial	Statistical analysis (t-test, Mann–Whitney U, Chi-square, Kaplan–Meier survival analysis)	DCC significantly improved packed cell volume at 2 h, with no increase in exchange transfusion, phototherapy duration, or adverse cardiac outcomes
10	(Shinohara et al., 2021)	Japanese infants have a relatively high risk of anemia and neonatal jaundice; DCC in East Asian populations with planned exclusive breastfeeding was lacking	Japan	Quantitative; Open-label Randomized Controlled Trial	Statistical analysis (t-test, Chi-square; intention-to-treat)	DCC did not significantly improve hemoglobin levels at 4 months compared with early cord clamping, although it significantly increased neonatal hematocrit levels within the normal range without increasing neonatal jaundice outcomes.

11	(Güner & Saydam, 2021)	High prevalence of infant anemia in Turkey; early cord clamping is routine despite evidence suggesting benefits of delayed clamping	Turkey	Quantitative; Parallel-group Randomized Controlled Trial	Statistical analysis (Student's t-test, Pearson χ^2 test)	Delayed clamping significantly increased 48-hour hematocrit, 4-month hemoglobin and hematocrit; no significant difference in phototherapy need

Appendix 3. JBI Study Quality Assessment

Table 3. Critical Appraisal for Randomized Controlled Trial (RCT)

No.	Critical Appraisal for RCT	(Mercer et al., 2016)	(Alzaree et al., 2018)	(KC et al., 2016)	(Dipak et al., 2017)	(Mangla et al., 2020)	(Mercer et al., 2018)	(De Bernardo et al., 2020)	(Yunis et al., 2021)	(Sahoo et al., 2020)	(Shinohara et al., 2021)	(Güner & Saydam, 2021)
1.	True randomization used	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.	Allocation concealed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3.	Groups similar at the baseline	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4.	Participants blinded	No	No	No	No	No	No	No	No	No	No	No
5.	Treatment delivery blind to treatment assignment	No	No	No	No	No	No	No	No	No	No	No
6.	Outcomes assessors blinded to treatment assignment	Yes	No	Yes	Yes	Unclear	Yes	Unclear	Yes	Yes	No	Yes
7.	Groups treated identically	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8.	Follow-up complete or described and analyzed	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

9.	Participants analyzed in their randomized group	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10.	Outcomes measured the same way	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11.	Outcomes measured reliably	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12.	Appropriate statistical analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13.	Trial design appropriate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix 4. PRISMA Checklist

Section and Topic	Item #	Checklist item	Item recorded
TITLE			
Title	1	Identify the report as a systematic review.	✓
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	✓
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	✓
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	✓
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	✓
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	✓
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	✓
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	✓
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	✓
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	✓

Section and Topic	Item #	Checklist item	Item recorded
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	✓
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	✓
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	✓
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	✓
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	✓
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	✓
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	✓
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	✓
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	✓
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	✓
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	✓
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	✓
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	✓
Study characteristics	17	Cite each included study and present its characteristics.	✓
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	✓
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	✓
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	✓
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	✓
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	✓
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	✓
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	✓

Section and Topic	Item #	Checklist item	Item recorded
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	✓
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	✓
	23b	Discuss any limitations of the evidence included in the review.	✓
	23c	Discuss any limitations of the review processes used.	✓
	23d	Discuss implications of the results for practice, policy, and future research.	✓
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	✓
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	✓
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	✓
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	✓
Competing interests	26	Declare any competing interests of review authors.	✓
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	✓